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Rocky Mountain Forest and  
Range Experiment Station

## A Computer Program to Calculate the Susceptibility of Spruce-Fir Stands to Spruce Beetle Outbreaks

J. A. Logan,<sup>1</sup> J. M. Schmid,<sup>2</sup> and M. S. Mehl<sup>3</sup>

The computer program shows spruce beetle hazard ratings directly from data collected for stage II timber inventories.

**Keywords:** *Abies lasiocarpa*, *Dendroctonus rufipennis*, *Picea engelmannii*, computer programs

Schmid and Frye (1976) presented a plan for rating the susceptibility of Engelmann spruce-subalpine fir (*Picea engelmannii* Parry and *Abies lasiocarpa* (Nutt.) Hooker) stands to spruce beetle (*Dendroctonus rufipennis* (Kirby)) infestation. The plan ranks the susceptibility of the stand based on its physiographic location, basal area, average diameter of the spruce, and percentage of spruce in the overstory.

During the past 5 years, inventory projects in the Rocky Mountain Region of the USDA Forest Service have been gathering intensive data on spruce-fir stands by the methods outlined in the 1980 edition of the Region's "Silvicultural Examination and Prescription Handbook" (FSH 2409.260). Substantial information is gathered for each stand, some of which is used in the Schmid-Frye system. The data are recorded on field forms and eventually are transferred to magnetic tapes which are stored in the project's headquarters.

Since its origin, the rating system has received limited use in the southern and central Rockies. To increase its usefulness to forest managers, a computer program was

written to calculate stand susceptibility from the inventory data. The program reads the inventory file for the stand, extracts the essential information, computes the stand rating, and prints it out, identifying the stand by the location data commonly recorded.

This program may give a slightly different rating for each stand from stage II inventory data than it would if the data were gathered in the same manner as was used to develop the rating system. In Schmid and Frye (1976), the limits for each category in the basal area, diameter, and percent spruce characteristics were based on data derived from fixed radius plots. Stage II data are derived from variable radius plots and different basal area factors. How this will affect the stand rating is not known at this time, but no significant change is assumed.

The program is compatible with USDA Forest Service, Rocky Mountain Region program processing data collected from the stage II inventory. The program could be integrated into the master program of the Region to run as a subroutine so that the stand rating for spruce beetles would be automatically included in the printout with the other stand information regularly presented. There is also the possibility of a computer-produced, differentially shaded or colored, overlay map representing a mosaic of standing ratings for the different stands in the spruce-fir forest. If the Schmid-Frye rating system is adopted with modifications for regional conditions in other western regions of the USDA Forest Service, this program can also be easily modified for use with it.

<sup>1</sup>Assistant Professor, Zoology and Entomology, Colorado State University.

<sup>2</sup>Entomologist, Rocky Mountain Forest and Range Experiment Station. Headquarters is at Fort Collins, in cooperation with Colorado State University.

<sup>3</sup>Forester, Timber Inventory, Rocky Mountain Region, USDA Forest Service, Fort Collins, Colo.

## Literature Cited

- Alexander, Robert R. 1967. Site indexes for Engelmann spruce. USDA Forest Service Research Paper RM-32, 7 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.
- Schmid, J. M., and R. H. Frye. 1976. Stand ratings for spruce beetles. USDA Forest Service Research Note RM-309, 4 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

## Appendix I

Once data for a specific stand has been isolated from the data file for all the stands using an add command in the Univac 1100 text editing routine from the Univac Manual UP-8723, program processing requires no additional input. The inventory file for the stand is searched by the program for information required for computation of stand spruce beetle susceptibility index. The program calls USDA Forest Service subroutine ESSITE for computation of site index based on Alexander (1967). On output, the program lists:

1. Alexander's site index
2. Total number of trees processed
3. Number of sample trees with d.b.h. greater than 2.6 inches

4. Number of sample spruce with d.b.h. greater than 10.0 inches
5. Stand risk rating from Schmid and Frye (1976)

Schmid/Frye Value	Program Output
4-5	Low
6	Low Medium
7-9	Medium
10	Medium High
11-12	High

See example problem

## Appendix II

### Program listing

```
C      ----PROGRAM TO ESTIMATE SUSCEPTIBILITY OF A SPRUCE STAND TO
C      ----SPRUCE BEETLE ATTACK
C
C      ----DATA INPUT IS STANDARD REGION-2 STAGE I/II STAND DATA
C      ----IT IS ASSUMED THAT DATA IS FOR SPRUCE STANDS ONLY
C      ----AS MANY SPRUCE STANDS AS NECESSARY CAN BE INPUTTED AT ONE TIME
C ***** USE UNIT 7 FOR DATA INPUT
C      DIMENSION X(4),IASCI(2,5),ASI(20),ITITL(12)
C      DATA IASCI/4HHIGH,1H ,4HMED ,4HHIGH,4HMEDI,2HUM,4HLOW ,3HMED,
C           13HLOW,1H /
C
C      ... TDBH = TOTAL LIVE DBH .GT. 2.6 IN
C      ... TSDBH = TOTAL LIVE SPRUCE .GT. 2.6 IN
C      ... TC = TOTAL DBH IN CANOPY .GT. 2.6 IN
C      ... TSC = TOTAL SPRUCE IN CANOPY .GT. 2.6 IN
C      ... SDBH10 = TOTAL SPRUCE .GT. IN REGARDLESS OF POSITION
C      ... XBAI IS BASIAL AREA INDEX
C      ... XHI = TREE HEIGHT
C      ... NUM=NUMBER OF ADDITIONAL STEMS
C      ... XAGE = TREE AGE
C
C      ...
C      ... ICNT = COUNTER FOR TOTAL TREES PROCESSED
C      ... ICNT2 = COUNTER FFR TREES OVER 2.6 IN. DBH
C      ... ICNT3 = COUNTER FFR SPRUCE OVER 10. DBH
C      ... NPLTS = COUNTER FOR NUMBER OF PLOTS
C      ... IPLTS1 = SECOND PLOT COUNTER
C      ... ISITC = COUNTER FOR SITE TREES
C      ...
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C ... RSK = SITE INDEX
TDBH=0.
TSDBH=0.
TC=0.
TSC=0.
SDBH10=0.
IUNIT=7
C
C ... READ HEADER CARD
197 CONTINUE
NPLTS=0
IPLTS1=0
ICNT=0
ICNT2=0
ICNT3=0
ISITC=0
IEND=0
READ(IUNIT,198,END=98) IDX1,IDX2,(ITITL(I),I=1,12)
198 FORMAT(2I6,1X,11A6,A1)
IUNIT=7
C ... DUMMY READ LOOP TO GET AT DATA
20 READ(IUNIT,199,END=98) ICT,IASCII2,IASCII1
C WRITE(6,199)ICT,IASCII2,IASCII1
199 FORMAT(12X,I1,16X,A2,8X,A1)
IF(ICT.NE.2)GO TO 21
DECODE(1,501,IASCII1)IRSK
501 FORMAT(I1)
C ...
C ... XBAI IS BASAL AREA INDEX FROM INPUT
555 FORMAT(10X,"IRSK,XBAI",I5,10X,1PE14.7)
C ...
C ... DECODE(2,502,IASCII2)XBAI
C WRITE(6,555)IRSK,XBAI
502 FORMAT(F2.0)
GO TO 20
21 CONTINUE
IF(ICT.NE.8)GO TO 20
C ... READ DATA CARDS
1 READ(IUNIT,101,END=98,ERR=99)ISIT1,ISIT2,ICT,IPLTS,ITH,ITSP,DBH,
1XHI,NUM,XAGE,ITPOS
101 FORMAT(2I6,I1,I3,7X,I2,I3,F3.1,F3.0,I2,5X,F3.0,10X,I1)
C ----CHECK FOR NEW STAND
IF(ICT.EQ.1) GO TO 505
C ... ISIT = SITE ID
C ... ICT= CARD TYPE
C ... ITH = TREE HISTORY -- "01" IS LIVE TREE -- "99" IS SITE TREE
C ... ITSP = TREE SPECIES
C ... DBH = DBH
C ... IRSK = PHYSIOLOGICAL LOCATION •IRSK=8 .THEN. HIGH RISK
C ...
C ... BRANCH TO READ IF NOT LIVE TREE
IF(IPLTS.NE.IPLTS1)NPLTS=NPLTS+1
IPLTS1=IPLTS
C ... CHECK FOR SITE TREE
IF(ITH.EQ.1)GO TO 2
IF(ITH.NE.99)GO TO 1
C ...
C ... TREE IS SITE TREE
C ... ASSUME TREE IS SPRUCE
C ... FROM FOREST SERVICE SUBROUTINE
ISITC=ISITC+1
CALL ESSITE(XHI,XAGE,ASI(ISITC))
60 TO 1
2 CONTINUE
NUM=NUM - 1
IF(NUM.LT.0) NUM=0
ICNT=ICNT + 1 + NUM
NUM=0
C ... DISREGARD TREE IF LESS THAN 2.6 IN.
IF(DBH.LT.2.6)GO TO 1
ICNT2=ICNT2+1
DDDH=(DBH/2.)/12.
DDH=DDDH*DDDH*3.2425962
C
500 WRITE(6,500)DBH,DDDH
FORMAT(10X,2(1PE14.7))
TDBH=TDBH+DDDH
6 IF(ITSP.GT.90)TSC=TSC+DDDH
6 IF(DBH.LT.10.)GO TO 1

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IF(ITSP.LT.90)GO TO 1
ICNT3=ICNT3+1
SDBH10=SDBH10+DBH
GO TO 1
98 IEND=1
GO TO 505
55 CONTINUE
C ----CHECK FOR ERROR IN DATA FORMAT
IF(ICK.EQ.1) GO TO 505
WRITE(6,504) ISIT1,ISIT2
504 FORMAT(" THERE HAS BEEN AN ERROR IN READING THE DATA FOR"
1" STAND ",2I6,/, " RUN TERMINATED")
STOP
505 CONTINUE
IF(IPLTS1.EQ.NPLTS)GO TO 7
C WRITE(6,503)NPLTS
503 FORMAT(10X,"ERROR -- PLOT NUMBER AND COUNT NOT EQUAL",
1/,10X,"NUMBER OF PLOTS COMPUTED AS = ",I4)
7 CONTINUE
C ... COMPUTE AVERAGE DIAMETER OF LIVE SPRUCE ABOVE 10. IN. DBH
C ... -- ALL LIVE SPRUCE TREES USED, BOTH CANOPY AND UNDERSTORY
IF(ICNT3.GT.0)GO TO 10
WRITE(6,300)
300 FORMAT(10X,"STAND CONTAINS ZERO SPRUCE ABOVE 10. IN. DBH",/
1,10X,"VARIABLE X(2) SET TO ZERO")
X(2)=0.
GO TO 19
10 X1=FLOAT(ICNT3)
C ... * * NOTE XBAI IS BASAL AREA INDEX * *
X(2)=SDBH10/X1
19 CONTINUE
C ... COMPUTE TOTAL STAND DBH REGARDLESS OF SPECIES OR TREE POSITION
C ... TREES MUST BE GREATER THAN 2.6 DBH TO BE INCLUDED
X1=ICNT2
X2=NPLTS
X(3)=(X1/X2)*XBAI
C ... COMPUTE PERCENT SPRUCE IN CANOPY - TREES .GT. 2.6 DBH ONLY
X(4)=100.* (TSC/TDBH)
C ... CONVERT RAW VALUES TO RISK VALUES
C WRITE(6,900)X(1),X(2),X(3),X(4)
900 FORMAT(10X,4(1PE14.7))
C ... SITE INDEX
IF(ISITC.LE.0)GO TO 600
C WRITE(6,*)"ISITC = ",ISITC
X1=ISITC
RSK=0.
DO 40 I=1,ISITC
C WRITE(6,*)"ASI(",I,") = ",ASI(I)
RSK=RSK+ASI(I)
40 CONTINUE
RSK=RSK/X1
X(1)=2.
IF(RSK.LT.80.)X(1)=1.
C ... CHECK FOR CREEK BOTTOM OR DRAW
IF(IRSK.EQ.8)X(1)=3.
C ... BEGIN OUTPUT
WRITE(6,603)(ITITL(I),I=1,12)
603 FORMAT(//,10X,"SPRUCE BEETLE STAND RATING FOR ",11A6,A1)
WRITE(6,601)RSK
601 FORMAT(10X,"ALEXANDERS SITE INDEX = ",F10.4)
X1=X(2)
X(2)=3.
IF(X1.LT.16.)X(2)=2.
IF(X1.LT.12.)X(2)=1.
X1=X(3)
X(3)=3.
IF(X1.LT.150.)X(3)=2.
IF(X1.LT.100.)X(3)=1.
X1=X(4)
X(4)=3.
IF(X1.LT.65.)X(4)=2.
IF(X1.LT.50.)X(4)=1.
C ... COMPUTE RISK SCORE
XRSK=0.
DO 30 I=1,4
XRSK=XRSK+X(I)
30 CONTINUE
IOUT=1

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IF(XRSK.LT.11.)IOUT=2
IF(SRSK.LT.10.)IOUT=3
IF(XRSK.LT.7.)IOUT=4
IF(XRSK.LT.6.)IOUT=5
WRITE(6,301)ICNT,ICNT2,ICNT3,(IASCI(I,IOUT),I=1,2)
301 FORMAT(10X,//,
110X,"TOTAL TREES PROCESSED IN STAND = ",I3,
2/10X,"TREES PROCESSED WITH DBH ≥ 6 IN. = ",I3,/
310X,"TREES PROCESSED WITH DBH ≥ 10.0 IN. = ",I3,///
410X,"STAND RISK RATING FOR SPRUCE BEETLE IS ",2A4,/)
C ----CHECK TO SEE IF END OF DATA
C IF(IEND.NE.0) STOP
C ----REREAD TITLE CARD FOR NEW STAND AND BEGIN PROCESSING NEW STAND
C IUNIT=30
C GO TO 197
C E00 CONTINUE
C WRITE(6,602)
C E02 FORMAT(10X,"NO SITE TREES -- PROGRAM ABORT")
C STOP
C END
C SUBROUTINE ESSITE(HT,AGE,SITE)
C SUBROUTINE TO COMPUTE SITE INDEX FOR ENGELMANN SPRUCE-REFERENCE
C ALEXANDER 1967 RESEARCH PAPER RM-32 TABLE 1.
C INPUT TREE HEIGHT (HT) AND BREAST HEIGHT AGE(AGE). OUTPUT SITE INDEX
C (SITE).
C DIMENSION HTSI(30,10), HROW(10), AG(30), SI(10)
C DATA HTSI/30*0.,4.5,6.,11.,15.,20.,24.,29.,33.,37.,40.,43.,46.,48.,
1,51.,53.,55.,56.,58.,59.,60.,61.,62.,2*63.,6*64.,4.5,9.,16.,22.,28
2.,33.,38.,42.,46.,50.,53.,56.,59.,61.,64.,66.,67.,69.,70.,71.,72.,
373.,2*74.,6*75.,4.5,13.,22.,29.,36.,42.,47.,52.,56.,60.,64.,67.,70
4.,72.,74.,76.,78.,80.,81.,82.,83.,84.,2*85.,6*86.,4.5,16.,27.,36.,
544.,50.,56.,61.,66.,70.,74.,77.,80.,83.,85.,87.,89.,90.,92.,93.,94
6.,2*95.,2*96.,5*97.,4.5,20.,33.,43.,52.,59.,65.,70.,75.,80.,84.,88
7.,91.,94.,96.,98.,100.,101.,103.,104.,105.,2*106.,2*107.,5*108.,4
85,23.,39.,50.,59.,67.,74.,80.,85.,90.,94.,98.,101.,104.,107.,109.,
9111.,112.,114.,115.,116.,2*117.,3*118.,4*119.,4.5,27.,44.,57.,67.,
176.,83.,89.,95.,100.,105.,109.,112.,115.,118.,120.,122.,123.,125.,
2126.,2*127.,128.,3*129.,4*130.,4.5,30.,50.,64.,75.,84.,92.,98.,104
3.,110.,115.,119.,123.,126.,129.,131.,133.,134.,135.,136.,137.,138.
4.,139.,3*140.,4*141.,4.5,34.,55.,71.,83.,93.,101.,108.,114.,120.,12
55.,130.,133.,136.,139.,142.,144.,145.,146.,147.,148.,149.,2*150.,2
6*151.,4*152./
C DATA AG/0.,20.,30.,40.,50.,60.,70.,80.,90.,100.,110.,120.,130.,140
1.,150.,160.,170.,180.,190.,200.,210.,220.,230.,240.,250.,260.,270.
2,280.,290.,300./
C DATA SI/0.,40.,50.,60.,70.,80.,90.,100.,110.,120./
C DATA HROW(1)/0./
TEM=AGE
IF(TEM.GT.300.)TEM=300.
DO 10 I=2,30
I1=I-1
I2=I
IF(AG(I)-TEM) 10,20,20
10 CONTINUE
20 DO 30 J=2,11
J1=J-1
J2=J
HROW(J)=(HTSI(I1,J)*(TEM-AG(I2))-HTSI(I2,J)*(TEM-AG(I1)))/(AG(I1)-
1AG(I2))
IF(HROW(J)-HT) 30,40,40
30 CONTINUE
40 IF(HROW(J)-HT) 50,60,60
50 SITE=120.
RETURN
60 SITE=(SI(J1)*(HT-HROW(J2))-SI(J2)*(HT-HROW(J1)))/(HROW(J1)-HROW(J
1))
RETURN
END

```

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?>#JOB. SEPARATOR#<?

### Appendix III

#### Example Run

- A. Data
- B. Program Execution
- C. Output

```

@DATA,L SPRUCEDATA.
DATA 9R1 SL74T9 08/15/80 09:23:57 (1)
      1. 1037070016121386 WILLIAMS CREEK
      2. 1037070016122020 94206797 00530300 01032 01X GA0111
      3. 103707001612408055031111010000000002 01
      4. 1037070016126F16C008G137742300203621025S068W06 115
      5. 1037070016128 0016
      6. 103707001612900101 01093077025 18039 008200 1
      7. 103707001612900102 01093128041 09156 018255 1
      8. 103707001612900103 01093070028 009200 1
      9. 1037070016129001 0109304001501 8
     10. 103707001612900104 01093000000 008 029 0 00 2
     11. 103707001612900105 01093000001 0 00 2
     12. 103707001612900106 01093000004 0 00 2
     13. 103707001612900201 01093159058 08168 019227 1
     14. 103707001612900202 01093182057 06224 019227 1
     15. 103707001612900203 01093058028 05090 008355 2
     16. 103707001612900204 01093144055 06220 009227 1
     17. 103707001612900205 01093140045 029227 1
     18. 103707001612900206 01093080033 019300 2
     19. 103707001612900207 01093027013 02804051 09300 2
     20. 103707001612900208 01093040019 02809065 09300 2
     21. 103707001612900209 01093033016 09300 2
     22. 103707001612900210 01093000003 0 00 2
     23. 103707001612900301 06093161024 3
     24. 103707001612900302 01102118025 8 2
     25. 103707001612900303 01102178027 8 2
     26. 103707001612900304 06102116021 3
     27. 103707001612900305 01093071027 009300 1
     28. 103707001612900306 01093056024 008300 2
     29. 103707001612900307 01093197046 05189 248252 1
     30. 103707001612900308 01093186048 148252 1
     31. 103707001612900309 01093065028 019255 1
     32. 103707001612900310 01093025012 08472 2
     33. 103707001612900311 01093028012 07451 2
     34. 103707001612900312 01093026009 07451 2
     35. 103707001612900313 01093015008 07451 2
     36. 103707001612900314 01093010007 07451 2
     37. 103707001612900401 01093090024 487228 2
     38. 103707001612900402 01093131028 029255 1 2
     39. 103707001612900402 99093131028 068 9255
     40. 103707001612900501 01093117034 008200 2
     41. 103707001612900502 01093071030 017255 2
     42. 103707001612900503 01093228075 06200 007255 1
     43. 103707001612900504 01093094033 008200 2
     44. 103707001612900505 01093013007 08400 2
     45. 103707001612900506 01093000001 0 00 2
     46. 103707001612900507 01093000000 0 00 2
     47. 103707001612900508 01093000000 0 00 2
     48. 103707001612900501 99093117034 048 8200 2

```

49. 103707001612900503 99093228075 200 7255 2  
END DATA. ERRORS: NONE. TIME: 0.723 SEC. IMAGE COUNT: 49

@FIN

@RUN,J/S R2TMRR,1102602411 ,INVADP,1,75/2000

@ASG,A SPRUCEDATA.

@ASG,A SPRUCEBEETLE.

@USE 7, SPRUCEDATA.

@XQT SPRUCEBEETLE.XQT

SPRUCE BEETLE STAND RATING FOR 386 WILLIAMS CREEK  
ALEXANDERS SITE INDEX = 50.9557

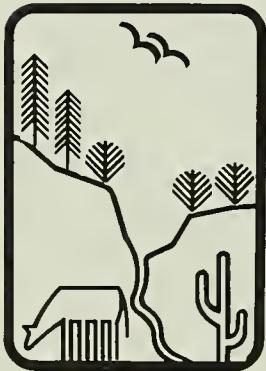
TOTAL TREES PROCESSED IN STAND = 39  
TREES PROCESSED WITH DBH >2.6 IN. = 28  
TREES PROCESSED WITH DRH>10.0 IN. = 12

STAND RISK RATING FOR SPRUCE BEETLE IS MEDIUM

@FIN



Rocky  
Mountains



Southwest



Great  
Plains

U.S. Department of Agriculture  
Forest Service

## Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

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